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U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

DOCKET #: 4925-193PUS

U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 10/030502

INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FI00/00635	**10 July 2000**	**09 July 1999**

TITLE OF INVENTION

Method For Creating Waveguides in Multilayer Ceramic Structures and a Waveguide

APPLICANT(S) FOR DO/EO/US

Olli SALMELA; Esa KEMPPINEN; Hans SOMERMA; Pertti IKÄLÄINEN; Markku KOIVISTO

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [x]This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. [x]This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [x]A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [x]A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [x]is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [x]has been transmitted by the International Bureau.
   c. [] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [x]Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [x]are transmitted herewith (required only if not transmitted by the International Bureau). **(See Reply to Written Opinion)**
   b. [] have been transmitted by the International Bureau.
   c. [] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [] have not been made and will not be made.
8. [] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [x]An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). **Unexecuted**
10. [] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. Below concern other document(s) or information included:

11. [x]An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [x]An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [x]A **FIRST** preliminary amendment.
    [] A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. [] A substitute specification.
15. [] A change of power of attorney and/or address letter.
16. [x]Other items or information *(specify):* PCT Publication Sheet, Int'l Preliminary Examination Report, Written Opinion, Reply to Written Opinion, Int'l Search Report, Notification Concerning Submission or Transmittal of Priority Document, Notice Informing the Applicant of the Communication of the International Application to the Designated Offices, Notification of the Record of a Change, Information Concerning Elected Offices Notified of Their Election, Notification of the Recording of a Change, PCT Request, PCT Demand

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U.S. APPLICATION NO (If known, see 37 C.F.R. 1.5) 10/030502	INTERNATIONAL APPLICATION NO PCT/FI00/00635	ATTORNEY'S DOCKET NUMBER 4925-193PUS

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17.[x]The following fees are submitted:					
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO .... **$890.00** International preliminary examination fee paid to USPTO (37 CFR 1.482).......... **$710.00** No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)).......... **$740.00** Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO .... **$1040.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) **$100.00**					
ENTER APPROPRIATE BASIC FEE AMOUNT =				$	890
Surcharge of **$130.00** for furnishing the oath or declaration later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	7 - 20 =		x **$18.00**	$	
Independent Claims	2 - 3 =		x **$84.00**	$	
Multiple dependent claim(s) (if applicable)			+ **$280.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$	890
Reduction of ½ for filing by small entity, if applicable.				$	
SUBTOTAL =				$	890
Processing fee of **$130.00** for furnishing the English translation later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$	890
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by the appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
				TOTAL FEES ENCLOSED	$890
				Amount to be refunded:	$
				charged:	$

a. [x]Two checks in the amounts of $ 890 and $ 40 to cover the above fees are enclosed.
b. [] Please charge my Deposit Account No. 03-2412 in the amount of $____ to cover the above fees. A duplicate copy of this sheet is enclosed.
c. [x]The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 03-2412. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
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By Express Mail # EV052762983US · January 8, 2002

Attorney Docket # 4925-193PUS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re National Phase PCT Application of

Olli SALMELA et al.

International Appln. No.: PCT/FI00/00635

International Filing Date: 07/10/2000

For: Method For Creating Waveguides in Multilayer Ceramic Structures and a Waveguide

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231
BOX PCT

S I R:

Prior to examination of the above-identified application please amend the application as follows:

IN THE SPECIFICATION:

Page 1, before line 1, the paragraph beginning "The invention relates to a method", insert the following heading:

--**FIELD OF THE INVENTION**--.

Page 1, before line 19, the paragraph beginning "Different conductor structures", insert the following heading:

--**<u>BACKGROUND OF THE INVENTION</u>**--.

Page 3, before line 13, the paragraph beginning "The objective of the invention", insert the following heading:

--**<u>SUMMARY OF THE INVENTION</u>**--.

Page 3, delete lines 34 and 35 (last two lines on page).

Page 4, before line 18, the paragraph beginning "In the following,", insert the following paragraph and heading:

-- Other objects and features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are intended solely for purposes of illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims.

<u>BRIEF DESCRIPTION OF THE DRAWINGS</u>--.

Page 5, before line 15, the paragraph beginning "Figure 1 was presented", insert the following heading:

--**<u>DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS</u>**--.

Page 10, after the last line on the page, insert the following paragraph:

--Thus, while there have been shown and described and pointed out fundamental novel features of the present invention as applied to preferred embodiments thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices described and illustrated, and in their operation, and of the methods described may be made by those skilled in the art without departing from the spirit of the present invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. Substitutions of elements from one described embodiment to another are also fully intended and contemplated. It is also to be understood that the drawings are not necessarily drawn to scale but that they are merely conceptual in nature. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.--.

Page 11, line 1, delete "Claims" and substitute therefore --What is claimed is:--.

IN THE CLAIMS:

Claims 1 to 7 have been amended to read as follows:

1. A method for manufacturing a waveguide in circuit structures manufactured with the multilayer ceramic technique, in which method the dimensions and structural

directions of the circuit structures can be determined by means of x, y and z axes perpendicular to each other, and the circuit unit is assembled of separate ceramic layers, the permittivity ε_1 of which is higher than the corresponding value of air, and in which layers cavities and holes of the desired shape are made and on the surface of which ceramic layer a conductive layer of material is silk screen printed on the desired location, and the circuit structure is completed by exposing the circuit structure to a high temperature, and in which method for creating a waveguide essentially in the direction of the z-axis

- at least two impedance discontinuities essentially parallel with the yz plane of the structure and of the length of the waveguide are formed in the circuit structure to limit the length a of the core part of the waveguide in the direction of the x-axis, which impedance discontinuities are accomplished by forming air-filled cavities essentially in the direction of the z-axis on both sides of the core part of the waveguide in the structure,

- and in the xz plane the core part of the waveguide is limited by essentially parallel first and second planes of conductive material, which are manufactured above and below the ceramic layers that form the core part of the waveguide in the direction of the y-axis, and which conductive first and second planes are used to limit the measure b of the core part of the waveguide in the direction of the y-axis.

2. A waveguide manufacturing method according to claim 1 wherein the two impedance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished

- by forming air-filled cavities essentially in the direction of the z-axis on both sides of the core part of the waveguide in the structure

- and by placing in the core part of the waveguide close to both air-filled cavities at least one row of vias filled with conductive material and essentially in the direction of the y-axis, by which said first and second planes of conductive material are galvanically connected.

3. A waveguide integrated into circuit units manufactured with the multilayer ceramic technique, wherein the dimensions and structural directions of the circuit units can be determined by means of x, y and z axis perpendicular to each other, and the circuit unit has been assembled of separate ceramic layers, the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities and holes of the desired shape have been made, and on the surface of which ceramic layers a layer of conductive material has been made on the desired location, which waveguide comprises:

- a core part of the waveguide essentially in the direction of the z-axis of the structure of the circuit unit,

- at least two impedance discontinuities essentially in the direction of the yz plane, essentially parallel and of the length of the waveguide, which limit the dimension a of the core part of the waveguide in the direction of the x-axis, which impedance discontinuities essentially in the direction of the yz plane have been formed by means of air-filled cavities and the interface of the core part, and

- a first layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide, and

- a second layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide, which first and second layers are essentially parallel and which limit the dimension b of the core part of the waveguide in the direction of the y-axis.

4. A waveguide according to claim 3, wherein said impedance discontinuities essentially in the direction of the yz plane have been formed

- of air-filled cavities placed essentially in the direction of the z-axis on both sides of the core part of the waveguide, and

- of vias essentially in the direction of the y-axis, filled with conductive material and placed in at least one row in the core part of the waveguide close to both air-filled cavities, by which vias said first and second layers have been connected.

5. A waveguide according to claim 3, wherein a hole has been made in the first surface of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

6. A waveguide according to claim 4, wherein a hole has been made in the first surface of the waveguide, through which hole a probe has been led to the core part of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

7. A waveguide according to claim 3, wherein a hole has been made in the first surface of the waveguide, through which hole a coupling loop has been led to the core part of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

REMARKS

This preliminary amendment is presented to place the application in proper form for examination. No new matter has been added. Early examination and favorable consideration of the above-identified application is earnestly solicited.

Any additional fees or charges required at this time in connection with the application may be charged to our Patent and Trademark Office Deposit Account No. 03-2412.

Respectfully submitted,
COHEN, PONTANI, LIEBERMAN & PAVANE

By: ______________________

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8 January 2002

By Express Mail # EV052762983US · January 8, 2002

AMENDMENTS TO THE SPECIFICATION AND CLAIMS SHOWING CHANGES

The claims have been amended as follows:

1. A method for manufacturing a waveguide in circuit structures manufactured with the multilayer ceramic technique, in which method the dimensions and structural directions of the circuit structures can be determined by means of x, y and z axes perpendicular to each other, and the circuit unit is assembled of separate ceramic layers **[(41, 61a, 61b)]**, the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities **[(22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c)]** and holes **[(38, 39, 48, 49, 64a, 64b)]** of the desired shape are made and on the surface of which ceramic layer a conductive layer of material **[(24, 25, 34, 35, 44, 45, 54a, 54b, 54b, 55a, 55b, 55c, 62a, 62b, 65a, 65b)]** is silk screen printed on the desired location, and the circuit structure is completed by exposing the circuit structure to a high temperature, and in which method for creating a waveguide essentially in the direction of the z-axis

- at least two impedance discontinuities essentially parallel with the yz plane of the structure and of the length of the waveguide are formed in the circuit structure to limit the length a of the core part **[(23, 33, 43, 53a, 53b, 53c)]** of the waveguide in the direction of the x-axis**<u>, which impedance discontinuities are accomplished by forming air-filled cavities essentially in the direction of the z-axis on both sides of the core part of the waveguide in the structure,</u>**

- and in the xz plane the core part **[(23, 33, 43, 53a, 53b, 53c)]** of the waveguide is limited by essentially parallel first **[(24, 34, 44, 54a, 54b, 54c, 62a, 62b)]** and second **[(25,**

35, 45, 55a, 55b, 55c, 65a, 65b)] planes of conductive material, which are manufactured above and below the ceramic layers that form the core part of the waveguide in the direction of the y-axis, and which conductive first and second planes are used to limit the measure b of the core part **[(23, 33, 43, 53a, 53b, 53c)]** of the waveguide in the direction of the y-axis **[characterized in that in the method for creating a waveguide essentially in the direction of the z-axis said two impediance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished by forming air-filled cavities (22, 26) essentially in the direction of the z-axis on both sides of the core part (23) of the waveguide in the structure]**<u>.</u>

2. A waveguide manufacturing method according to <u>claim</u> **[Claim]** 1 **[, characterized in that]** <u>wherein the</u> two impedance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished

- by forming air-filled cavities **[(32, 36)]** essentially in the direction of the z-axis on both sides of the core part **[(33)]** of the waveguide in the structure

- and by placing in the core part **[(33)]** of the waveguide close to both air-filled cavities **[(32, 36)]** at least one row of vias **[(38, 39)]** filled with conductive material and essentially in the direction of the y-axis, by which said first **[(34)]** and second **[(35)]** planes of conductive material are galvanically connected.

3. A waveguide integrated into circuit units manufactured with the multilayer ceramic technique, wherein the dimensions and structural directions of the circuit units can be determined by means of x, y and z axis perpendicular to each other, and the circuit unit has been assembled of separate ceramic layers **[(41, 61a, 61b)]**, the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities **[(22, 26, 32, 36, 42, 52a, 52b, 52c, 56a, 56b, 56c)]** and holes **[(38, 39, 48, 49, 64a, 64b)]** of the desired shape have been made, and on the surface of which ceramic layers a layer of conductive material has been made on the desired location, which waveguide comprises:

- a core part of the waveguide **[(23, 33, 43, 53a, 53b, 53c)]** essentially in the direction of the z-axis of the structure of the circuit unit,

- at least two impedance discontinuities essentially in the direction of the yz plane, essentially parallel and of the length of the waveguide, which limit the dimension a of the core part **[(23, 33, 43, 53a, 53b, 53c)]** of the waveguide in the direction of the x-axis**, which impedance discontinuities essentially in the direction of the yz plane have been formed by means of air-filled cavities and the interface of the core part**, and

- a first **[(24, 34, 44, 54a, 54b, 54c, 62a, 62b)]** layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide, and

- a second **[(25, 35, 45, 55a, 55b, 55c, 65a, 65b)]** layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide, which first and second layers are essentially parallel and which limit the dimension b of the core part **[(23, 33, 43, 53a, 53b, 53c)]** of the waveguide in the direction of the y-axis **[characterized in**

that said impedance discontinuities essentially in the direction of the yz plane have been formed by means of the air-filled cavities (22, 26) and the interface of the core part (23)].

4. A waveguide according to **claim** **[Claim]** 3, **[characterized in that]** **wherein** said impedance discontinuities essentially in the direction of the yz plane have been formed

- of air-filled cavities **[(32, 36)]** placed essentially in the direction of the z-axis on both sides of the core part of the waveguide, and

- of vias **[(38, 39)]** essentially in the direction of the y-axis, filled with conductive material and placed in at least one row in the core part **[(33)]** of the waveguide close to both air-filled cavities, by which vias said first and second layers have been connected.

5. A waveguide according to **[Claim]** **claim** 3, **wherein** **[characterized in that]** a hole **[(58a)]** has been made in the first surface **[(54a)]** of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

6. A waveguide according to **[Claim]** **claim** 4, **wherein** **[characterized in that]** a hole **[(58b)]** has been made in the first surface **[(54b)]** of the waveguide, through which hole a probe **[(59b)]** has been led to the core part **[(53b)]** of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

7. A waveguide according to **[Claim]** **claim** 3, **wherein** **[characterized in that]** a hole **[(58c)]** has been made in the first surface **[(54c)]** of the waveguide, through which hole a coupling loop **[(59c)]** has been led to the core part **[(53c)]** of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

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Method for creating waveguides in multilayer ceramic structures and a waveguide

The invention relates to a method for creating waveguides in circuit board units manufactured with the multilayer ceramic technique, in which method the dimensions and structural directions of the circuit board units can be defined by means of x, y and z axes perpendicular to each other, and the circuit board unit is assembled of separate ceramic layers, the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities and holes of the desired shape can be made, and on the surface of which ceramic layer a conductive material can be printed at the desired location by silk screen printing, and the circuit board unit is completed by exposing the unit to a high temperature.

The invention also relates to a waveguide integrated into circuit board units manufactured with multilayer ceramics, wherein the dimensions and structural directions of the circuit board units can be defined by means of x, y and z axes perpendicular to each other, and the circuit board unit has been assembled of separate ceramic layers, the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities and holes of the desired shape have been made in the ceramic layers, and on the surface of which ceramic layers a layer of conductive material can be added at the desired location by silk screen printing.

Different conductor structures are used in the structures of electronic devices. The higher the frequencies used in the devices, the greater the requirements set for the conductor structures used, so that the attenuation caused by the conductor structures does not become too high or that the conductor structure used does not disturb other parts of the apparatus by radiation. The designer of the device can select from many possible conductor structures. Depending on the application, an air-filled waveguide made of metal, for example, can be used. The basic structure, dimensions, waveforms that can propagate in the waveguide and the frequency properties of the waveguide are well known (see e.g. chapter 8 Fields and Waves in Communication Electronics, Simon Ramo et al., John Wiley & Sons, inc., USA). Fig. 1 shows, as an example of the dimensioning of a waveguide, a rectangular waveguide made of conductive material, the width of which is a in the direction of the x-axis of the coordinates shown in the figure, the height of which is b in the direction of the y-axis, and which is filled by air, whereby its permittivity ε_r is of magnitude 1. In the

air-filled waveguide shown in Fig. 1, the first (lowest) waveform that can propagate in the direction of the z-axis is the so-called TE_{10} (Transverse-electric) waveform. The electric field E of this waveform does not have a component in the direction of the z-axis at all. Instead, the magnetic field H has a component in the direction of propagation, the direction of the z-axis. The so-called cut-off frequency f_c of the waveform TE_{10}, which means the lowest frequency that can propagate in the waveguide, is obtained from the equation:

$$f_{cTE_{10}} = {}^{c}\!/_{2a}$$

where the letter a means the width a of the waveguide in the direction of the x-axis, and c is the speed of light in a vacuum. Generally, the usable frequency range of the waveguide is 1.2 to 1.9 times the cut-off frequency of the waveform in question. The usable lower limiting frequency is determined by the growth of the attenuation when the cut-off frequency f_c is approached from above. The upper frequency limit again is determined by the fact that with frequencies that are more than twice the cut-off frequency f_c of the desired waveform, other waveforms that are capable of propagating are also created in the waveguide, and this should be avoided.

There are also known waveguide structures, in which the waveguide is formed by a core part made of dielectric material, which is coated with a thin layer of conductive material. However, these waveguides are always made as separate components. The above described waveguide structures provide a small attenuation per unit of length, and they do not emit much interference radiation to the environment. However, the problem with these waveguides is the large physical size compared to the rest of the circuit unit to be manufactured, and the fact that it is difficult to integrate their manufacture into the manufacture of the circuit unit as a whole. These waveguides must be joined to the circuit unit mechanically either by soldering or by some other mechanical joint in a separate step, which increases costs and the risk of failure.

Conductor structures that are better integrated into the structure are also utilized in electronic equipment. These include strip lines, microstrips and coplanar conductors. Their manufacture can be integrated into the manufacture of the circuit unit as a whole, when circuit units are manufactured as ceramic structures. This manufacturing technique is called multilayer ceramics, and it is based either on the HTCC (High Temperature Cofired Ceramics) or LTCC (Low Temperature Cofired Ceramics) technique. The circuit structures implemented with either of these manufacturing techniques consist of multiple layers of ceramic material (green tape), which are 100 µm thick and placed on top of each other when the circuit

structure is assembled. Before the heat treatment, which is performed as the final treatment, the ceramic material is still soft, and thus it is possible to make cavities and vias of the desired shape in the ceramic layers. It is also possible to make various electrically passive elements and the above-mentioned conductors on the desired points with silk screen printing. When the desired circuit unit is structurally complete, the ceramic multilayer structure is fired in a suitable temperature. The temperature used in the LTCC technique is around 850°C and in the HTCC technique around 1600°C. However, the problem of microstrips, strip lines and coplanar conductors made with these techniques is the high attenuation per unit of length, low power margin and relatively low ElectroMagnetic Compatibility (EMC). These problems limit the use of these conductor structures in the applications where the above-mentioned properties are needed.

The objective of the invention is to accomplish a waveguide structure implemented with multilayer ceramics, by which the above-mentioned drawbacks of the prior art guide structure can be reduced.

The method according to the invention is characterized in that for creating a waveguide in the direction of the z-axis:
- at least two impedance change points in the direction of the yz plane of the structure are formed in the structure to limit the length a of the core of the waveguide in the direction of the x-axis, and
- that in the xz plane, the core of the waveguide is limited with a first and a second layer of conductive material, which is silk screen printed on top of the ceramic layers that form the core of the waveguide, and which conductive planes are used to limit the length b of the core of the waveguide in the direction of the y-axis.

The waveguide according to the invention is characterized in that it comprises:
- the core part of the waveguide of the structure of the circuit unit in the direction of the z-axis,
- at least two points of impedance discontinuity in the yz-plane, by which the length a of the core part of the waveguide has been limited in the direction of the x-axis, and
- a first and a second layer of conductive material in the xz plane, by which layers the dimension b of the core part of the waveguide has been limited in the direction of the y-axis.

Some preferred embodiments of the invention are described in the dependent claims.

The basic idea of the invention is the following: A waveguide fully integrated into the structure is manufactured with the multilayer ceramic technique. The core part of the waveguide is made of dielectric material with a suitable permittivity ε_r, which is separated from the rest of the ceramic structure in one plane by two layers of conductive material forming parallel planes, and in another plane, which is perpendicular to the previous planes, by two cavities filled with air and/or joining holes filled with conductive material.

The invention has the advantage that the waveguide can be manufactured simultaneously with other components manufactured with the multilayer ceramic technique.

In addition, the invention has the advantage that the feeding arrangement of the waveguide can be implemented with the same multilayer ceramic technique.

The invention also has the advantage that the manufacturing costs of a waveguide manufactured with the method are lower than those of a waveguide made of separate components and joined to the structure in a separate step.

Furthermore, the invention has the advantage that it has a good EMC protection as compared to a strip line, microstrip or coplanar conductor.

In the following, the invention will be described in more detail. Reference will be made to the accompanying drawings, in which

Figure 1 shows an ordinary, air-filled waveguide made of conductive material,

Figure 2 shows an exemplary embodiment implemented with the multilayer ceramic technique, in which the side walls of the waveguide are formed of cavities filled with air,

Figure 3 shows another exemplary embodiment implemented with the multilayer ceramic technique, in which the side walls of the waveguide are formed of air-filled cavities and vias in the vicinity thereof, filled with conductive material,

Figure 4 shows an example of a waveguide according to the second embodiment of the invention implemented with the multilayer ceramic technique as a section in the x-y plane,

Figure 5a shows an example of one way according to the invention to excite a waveform capable of propagating in the waveguide according to the first embodiment of the invention,

Figure 5b shows an example of another way according to the invention to excite a waveform capable of propagating in the waveguide according to the first embodiment of the invention,

Figure 5c shows an example of a third way according to the invention to excite a waveform capable of propagating in the waveguide according to the first embodiment of the invention,

Figure 6a shows an yz-plane presentation of one way of joining a waveguide according to an embodiment of the invention to a microstrip conductor, and

Figure 6b shows an yz-plane presentation of fitting the feeding point of a waveguide according to the invention to a waveguide.

Figure 1 was presented in connection with the description of the prior art. In connection with the description of Figures 2 to 6, reference is made to the directions of the axes x, y and z shown in Figure 1. The directions of the axes are the same as those shown in the example of Fig. 1, although the axes are not drawn in all the figures.

Figure 2 shows an example of a waveguide according to the first embodiment of the invention, implemented with the multilayer ceramic technique. The structure shown in Fig. 2 is part of a larger circuit structure implemented with the multilayer ceramic technique, which is not shown in its entirety in the drawing. The waveguide structure is surrounded on both sides by the structures 21 and 27 shown in the drawing, which consist of several green tapes. The permittivity ε_r of the ceramic material used in them is clearly higher than the permittivity of air, which is of the magnitude 1, as is well known. Other parts of the structure, which are both above and below the waveguide structure shown in the drawing, viewed in the direction of the y-axis, consist mainly of the same ceramic material. The core part 23 of the waveguide consists of the same ceramic material as the rest of the circuit structure. The width of the waveguide in the direction of the x-axis is limited by air-filled cavities 22 and 26 essentially in the direction of the yz plane. The interface of the air-filled cavity 22 or 26 forms a discontinuity of the characteristic impedance against the core part 23 in view of the electromagnetic wave front. This

discontinuity of the characteristic impedance mainly reflects the wave front, which is capable of propagating in the core part 23 of the waveguide, back to the core part 23, while the wave front propagates in the direction of the z-axis. The waveguide is limited in the xz-plane by a first surface 24 and a second surface 25, which are made of some conductive material and which form essentially parallel planes. These planar surfaces 24 and 25 can be made either such that they completely cover the core part 23 or partly gridded. These planar, conductive surfaces 24 and 25 can be made, for example, of conductive pastelike material, by metallizing the surfaces of the core part 23 in these planes or also by covering the core part 23 by separate, thin, conductive filmy material.

In the waveguide according to the first embodiment of the invention, the lowest possible propagating waveform is the TEM (Transverse-electromagnetic) waveform, the electric or magnetic field of which does not have a component in the direction of the z-axis of the drawing. The cut-off frequency of this waveform is 0 Hz, as is known, which means that direct current can flow in the waveguide. A waveguide according to the first embodiment of the invention can also transmit other higher, possibly desired TE_{mn} or TM_{mn} (Transverse-magnetic) waveforms, the corresponding cut-off frequencies of which can be calculated according to the dimensioning rules of an ordinary waveguide, which dimensioning rules have been presented in connection with the description of Fig. 4.

Figure 3 shows an example of a waveguide according to the second embodiment of the invention. The structure shown in Fig. 3 is part of a larger structure implemented with the multilayer ceramic technique, which is not shown in its entirety in the drawing. The waveguide structure is surrounded on both sides by the structures 31 and 37 shown in the drawing, which consist of several green tapes. The permittivity ε_r of the ceramic material used in them is clearly higher than the permittivity of air, which is of the magnitude 1. Other parts of the structure, which are both above and below the waveguide structure shown in the drawing, viewed in the direction of the y-axis of the drawing, also consist mainly of the same ceramic material. The core part 33 of the waveguide consists of the same ceramic material as the rest of the circuit structure. The width of the waveguide in the direction of the x-axis is limited by two essentially parallel impedance discontinuities, which are formed of via posts 38 and 39 in the direction of the y-axis of the drawing together with the air-filled cavities 32 and 36. The air-filled cavities 32 and 36 have a similar construction as was presented in connection with the description of the cavities shown in Fig. 2. The via posts 38, 39 are filled with conductive, pastelike material in connection with the

manufacture of the circuit structure. When the LTCC technique is used, either AgPd paste or Ag paste can be used advantageously. If the waveguide structure according to the invention is entirely surrounded from all sides by other ceramic layers, the cheaper Ag paste can be used. If part of the created waveguide structure remains exposed to the external atmosphere, the more expensive AgPd paste must be used. The via posts 38, 39 combine the essentially parallel first plane 34 and second plane 35, which are formed of conductive material and which limit the core part 33 in the xz plane.

In the embodiment shown in Fig. 3, one via post 38 and 39 for each side of the core part are shown in the drawing as viewed in the direction of the x-axis. The waveguide structure according to the invention can also be implemented by adding several similar via posts to the core part 33. It is also possible to add more similar via posts to the parts 31 and 37 of the circuit structure behind the air cavities 32 and 36, whereby the EMC properties of the waveguide are further improved.

Figure 4 shows an example of a structure according to the second embodiment of the invention as a section in the xy plane. The ceramic circuit structure is assembled by layers of ceramic plates/strips 41. The waveguide is separated from the rest of the structure in the direction of the x-axis by air-filled cavities 42 and 46 in the direction of the yz plane, the width of which cavities is the measure L shown in the drawing and the height is the measure b shown in the drawing, and via posts 48 and 49 filled with conductive material. The core part 43 of the waveguide is formed by ceramic material, the permittivity ε_r of which is high compared to air. The width of the core part of the waveguide in the direction of the x-axis in denoted by the letter a in the drawing. The width L of the air-filled cavities 42 and 46 in the x-plane is selected such that its magnitude corresponds to a fourth of the wavelength of the cut-off frequency f_c. Then the waveguide structure emits as little interference radiation as possible to its environment. In the xz plane, which is perpendicular to the surface shown in Fig. 4, the waveguide is limited by a first plane 44 and a second plane 45, which are essentially parallel and made of conductive material. The first plane 44 and the second plane 45 are connected to each other by vias 48 and 49, which are filled with conductive material. The waveforms TE_{mn} and TM_{mn} can propagate in a waveguide according to the embodiment shown in the drawing. The cut-off frequencies f_{cmn} of these waveforms are obtained from the known formula:

$$f_{cm,n} = \frac{1}{2\sqrt{\mu\ \varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

In the formula, the indexes m and n refer to the number of maximums in the direction of the x and y axes of the transverse field distribution of the TE_{mn} or TM_{mn} waveform, measure a denotes the width of the waveguide in the direction of the x-axis, and measure b denotes the height of the waveguide in the direction of the y-axis. The terms μ and ε in the formula are the permeability and permittivity values of the ceramic material of the core part 43 of the waveguide.

Figures 5a, 5b and 5c show three different examples of how the desired waveform can be excited in waveguides according to the invention. The waveguide used in the examples of the figures is a waveguide according to the first embodiment, but the solutions function in accordance with the same principle in waveguide structures according to the second embodiment of the invention as well.

In the example of Figure 5a, the core 53a of the waveguide is separated from the rest of the circuit structure, which is represented by parts 51a and 57a of the structure in the drawing, by air-filled cavities 52a and 56a and a first plane 54a and a second plane 55a, which are essentially parallel and made of conductive material. In order to excite the desired waveform, a hole 58a has been made at the desired point in the first plane 54a of the waveguide. When a radiating element, which is not shown in the drawing, is placed in the vicinity of the hole 58a, the result is that part of the field radiated by the element is transferred through the hole 58a to the waveguide according to the invention. The radiating element can be any circuit element capable of radiating, or possibly another waveguide according to the invention, in the wall of which a hole of corresponding shape and capable of radiating has been made. By selecting the radiating frequency correctly, an electromagnetic waveform of the desired kind and capable of propagating can be excited in the waveguide.

Figure 5b shows another possible way of exciting a waveform capable of propagating in a waveguide according to the invention. In the example of Figure 5b, the core 53b of the waveguide is separated from the rest of the circuit structure, which is represented in the drawing by parts 51b and 57b, by air-filled cavities 52b and 56b and a first plane 54b and a second plane 55b, which are essentially parallel and made of conductive material. In order to excite the desired waveform, there is a hole 58b made at the desired point of the conductive first plane 54b, and the hole is fitted with a cylindrical probe 59b leading to the core part 53b of the waveguide.

The probe is preferably made of the same conductive material as the planar first surface 54b and second surface 55b of the waveguide. The probe 59b is connected to the desired signal inputting conductor in the circuit structures above the planar first surface 54b. The signal conductor can be a strip line or a microstrip, for example. The conductor and other circuit structures above are not shown in Fig. 5b.

Figure 5c shows a third possible way of exciting a waveform capable of propagating in a waveguide according to the invention. In the example of Figure 5c, the core 53c of the waveguide is separated from the rest of the unit, which is represented in the drawing by parts 51c and 57c, by air-filled cavities 52c and 56c and a first plane 54c and a second plane 55c, which are essentially parallel and made of conductive material. In order to excite the desired waveform in the waveguide, there is a hole 58c made at the desired point of the first plane 54c made of conductive material, and the hole is fitted with a coupling loop 59c leading to the core part 53c of the waveguide. The coupling loop 59c is connected to the desired signal inputting conductor in the circuit structures above the planar first surface 54c. The signal conductor can be, for example, a stripline, microstrip or a coplanar conductor. The signal inputting conductor and other circuit structures above are not shown in Fig. 5c. The coupling loop 59c is manufactured of conductive material in connection with the manufacture of the rest of the circuit structure implemented with the multilayer ceramic technique.

Figure 6a shows, by way of example, how the microstrip and the waveguide according to the invention can be joined together. The figure shows a section in the yz plane of the point where the conductors are connected. The circuit structure has been implemented by joining together several layers of ceramic plates 61a. The portion of the microstrip 60a is formed by the signal conductor 63a and the ground conductor 62a. The impedance of the transmission line changes at the point where the microstrip and the waveguide 68a are joined together. High impedance mismatches cause an undesired reflection of the signal back to its incoming direction in the above-mentioned interface. This reflection problem can be diminished by making at the joint a special structure, in which the impedance level of the transmission line is gradually changed. In the example of Fig. 6a, this matching of the impedances has been implemented by a so-called quarter-wave transformer 67a. It consists of steplike changes of the waveguide geometry of the length of $\lambda/4$ in the direction of the z-axis in the drawing. In Fig. 6a, it is accomplished by means of conductive plane surfaces 66a, which are connected to each other in the direction of the y-axis by vias 64a made of conductive material. In

the direction of the x-axis, these planes 66a reach across the whole core part of the waveguide. The electric properties of the ceramic material used in the structure are similar in all parts of the circuit structure in the example of the drawing.

Figure 6b shows an example of another way of joining a waveguide according to the invention to another electric circuit. The figure shows a section in the yz plane of the point where the transmission lines are connected. The circuit structure of the component has been implemented by joining together several layers of ceramic plates 61b. The exciting signal is brought to the waveguide by means of a cylindrical probe 63b. In the example of the drawing, the probe comes to the waveguide 68b through the first plane 62b, which forms the upper surface of the waveguide, and a hole 69b made in the plane. Thus the probe 63b does not have a galvanic connection to the conductive first plane 62b. The probe 63b itself may reach through several ceramic circuit structures in the direction of the y-axis of the drawing, when required. The impedance mismatch created at the feeding point of the signal is reduced by a quarter-wave transformer 67b of the kind described in connection with Figure 6a. The quarter-wave transformer 67b consists of conductive plane surfaces 66b, which are connected to each other in the direction of the y-axis of the drawing by vias 64b made of conductive material. In the direction of the x-axis of the drawing, these planes 66b reach across the whole core part of the waveguide. The electric properties of the ceramic material used in the structure are similar in all parts of the circuit structure in the example of the drawing.

Calculatory simulations have been performed on the embodiments of the waveguides according to the invention. The simulations have been performed on both embodiments according to the invention with the same structural dimensions, whereby the measure a of the core part of the waveguide has been 5 mm, measure b 2 mm, ε_r of the ceramic material 5.9 and the measure L in the direction of the x-axis of the air-filled cavities that are part of the waveguide structure 2.5 mm. A mode of operation according to TE_{10} has been used in the simulation, and the frequency used has been 18 GHz. As a result of the simulation, the first embodiment according to the invention had an attenuation of 1.7 dB/cm. With the same structural dimensions a and b and the same frequency 18 GHz, the waveguide structure according to the second embodiment of the invention had an attenuation value of 0.7 dB/cm.

Some preferred embodiments of the invention have been described above. However, the invention is not limited to the solutions described above. The inventive idea can be applied in many different ways within the scope defined by the attached claims.

Claims

1. A method for manufacturing a waveguide in circuit structures manufactured with the multilayer ceramic technique, in which method the dimensions and structural directions of the circuit structures can be determined by means of x, y and z axes perpendicular to each other, and the circuit unit is assembled of separate ceramic layers (41, 61a, 61b), the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities (22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c) and holes (38, 39, 48, 49, 64a, 64b) of the desired shape are made and on the surface of which ceramic layer a conductive layer of material (24, 25, 34, 35, 44, 45, 54a, 54b, 54c, 55a, 55b, 55c, 62a, 62b, 65a, 65b) is silk screen printed on the desired location, and the circuit structure is completed by exposing the circuit structure to a high temperature, and in which method for creating a waveguide essentially in the direction of the z-axis
- at least two impedance discontinuities essentially parallel with the yz plane of the structure and of the length of the waveguide are formed in the circuit structure to limit the length a of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the x-axis,
- and in the xz plane the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide is limited by essentially parallel first (24, 34, 44, 54a, 54b, 54c, 62a, 62b) and second (25, 35, 45, 55a, 55b, 55c, 65a, 65b) planes of conductive material, which are manufactured above and below the ceramic layers that form the core part of the waveguide in the direction of the y-axis, and which conductive first and second planes are used to limit the measure b of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the y-axis,

characterized in that

in the method for creating a waveguide essentially in the direction of the z-axis said two impedance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished by forming air-filled cavities (22, 26) essentially in the direction of the z-axis on both sides of the core part (23) of the waveguide in the structure

2. A waveguide manufacturing method according to Claim 1, **characterized** in that two impedance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished

- by forming air-filled cavities (32, 36) essentially in the direction of the z-axis on both sides of the core part (33) of the waveguide in the structure
- and by placing in the core part (33) of the waveguide close to both air-filled cavities (32, 36) at least one row of vias (38, 39) filled with conductive material and essentially in the direction of the y-axis, by which said first (34) and second (35) planes of conductive material are galvanically connected.

3. A waveguide integrated into circuit units manufactured with the multilayer ceramic technique, wherein the dimensions and structural directions of the circuit units can be determined by means of x, y and z axis perpendicular to each other, and the circuit unit has been assembled of separate ceramic layers (41, 61a, 61b), the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities (22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c) and holes (38, 39, 48, 49, 64a, 64b) of the desired shape have been made, and on the surface of which ceramic layers a layer of conductive material has been made on the desired location, which waveguide comprises:
- a core part of the waveguide (23, 33, 43, 53a, 53b, 53c) essentially in the direction of the z-axis of the structure of the circuit unit,
- at least two impedance discontinuities essentially in the direction of the yz plane, essentially parallel and of the length of the waveguide, which limit the dimension a of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the x-axis, and
- a first (24, 34, 44, 54a, 54b, 54c, 62a, 62b) layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide, and
- a second (25, 35, 45, 55a, 55b, 55c, 65a, 65b) layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide,

which first and second layers are essentially parallel and which limit the dimension b of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the y-axis,

characterized in that

said impedance discontinuities essentially in the direction of the yz plane have been formed by means of the air-filled cavities (22, 26) and the interface of the core part (23).

4. A waveguide according to Claim 3, **characterized** in that said impedance discontinuities essentially in the direction of the yz plane have been formed
- of air-filled cavities (32, 36) placed essentially in the direction of the z-axis on both sides of the core part of the waveguide, and
- of vias (38, 39) essentially in the direction of the y-axis, filled with conductive material and placed in at least one row in the core part (33) of the waveguide close to both air-filled cavities, by which vias said first and second layers have been connected.

5. A waveguide according to Claim 3, **characterized** in that a hole (58a) has been made in the first surface (54a) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

6. A waveguide according to Claim 4, **characterized** in that a hole (58b) has been made in the first surface (54b) of the waveguide, through which hole a probe (59b) has been led to the core part (53b) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

7. A waveguide according to Claim 3, **characterized** in that a hole (58c) has been made in the first surface (54c) of the waveguide, through which hole a coupling loop (59c) has been led to the core part (53c) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

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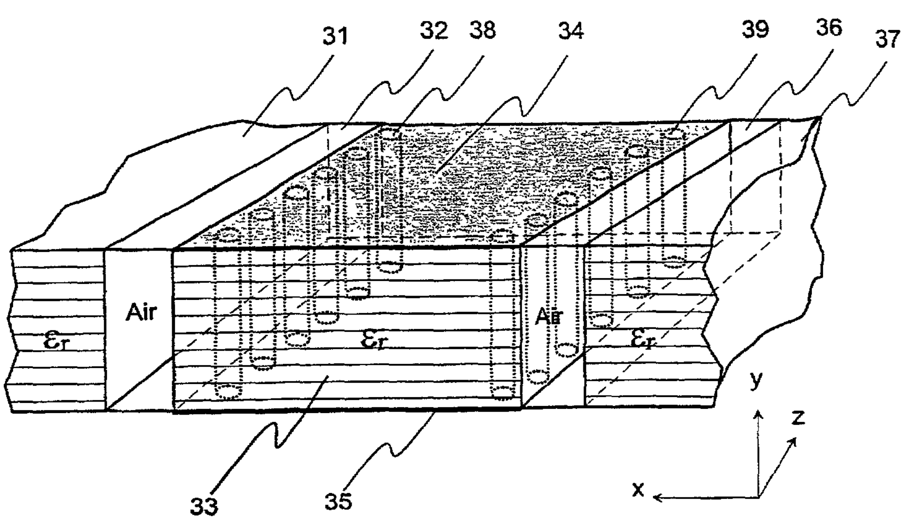
[Continued on next page]

(54) Title: METHOD FOR CREATING WAVEGUIDES IN MULTILAYER CERAMIC STRUCTURES AND A WAVEGUIDE



(57) Abstract: The invention relates to a waveguide manufacturing method and a waveguide manufactured with the method, which can be integrated into a circuit structure manufactured with the multilayer ceramic technique. The core part (23, 33, 43, 53a, 53b, 53c) of the waveguide is formed by a unit assembled of ceramic layers, which is limited in the yz plane by two impedance discontinuities and in the xz plane by two planar surfaces (24, 25, 34, 35, 54a, 54b, 54c, 55a, 55b, 55c) made of conductive material. The conductive surfaces can be connected to each other by vias made of conductive material (38, 39, 48, 49). The waveguide manufactured with the method according to the invention is a fixed part of the circuit structure as a whole.

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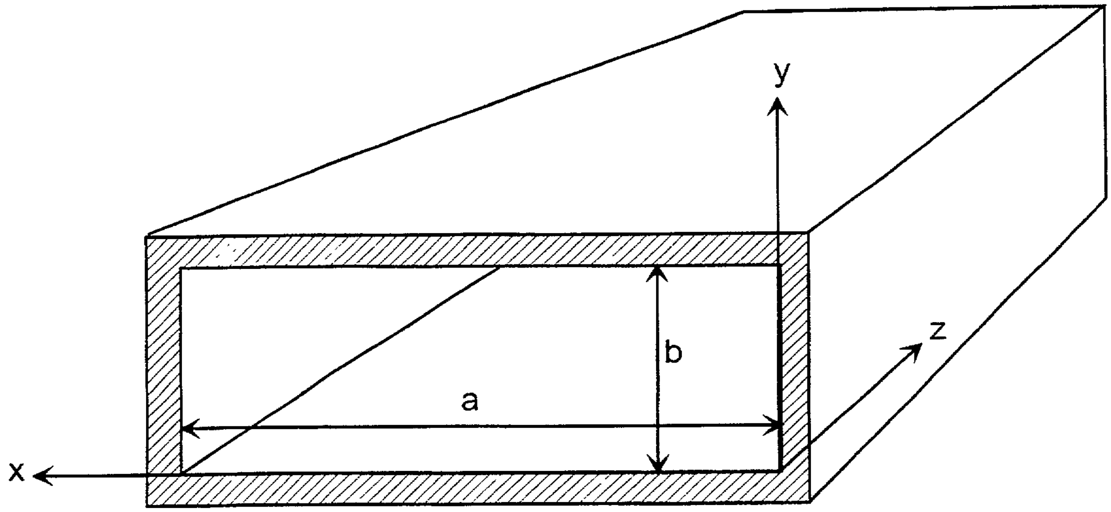

Fig. 1

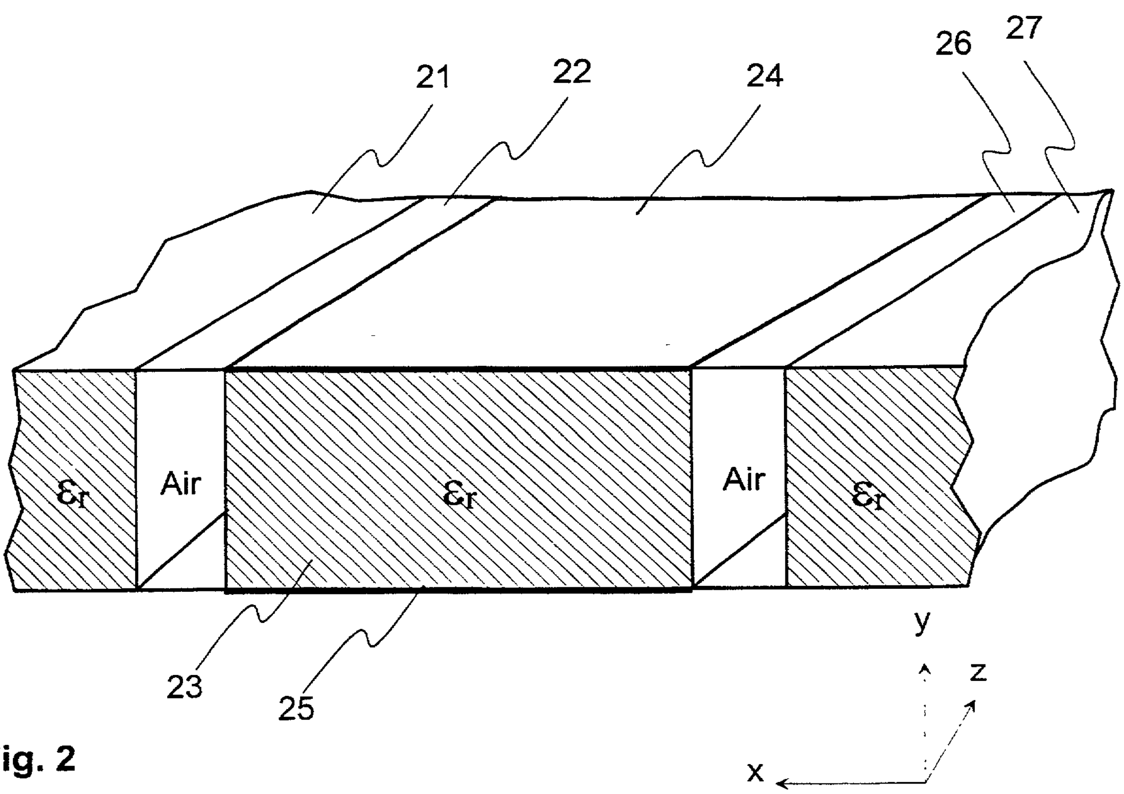

Fig. 2

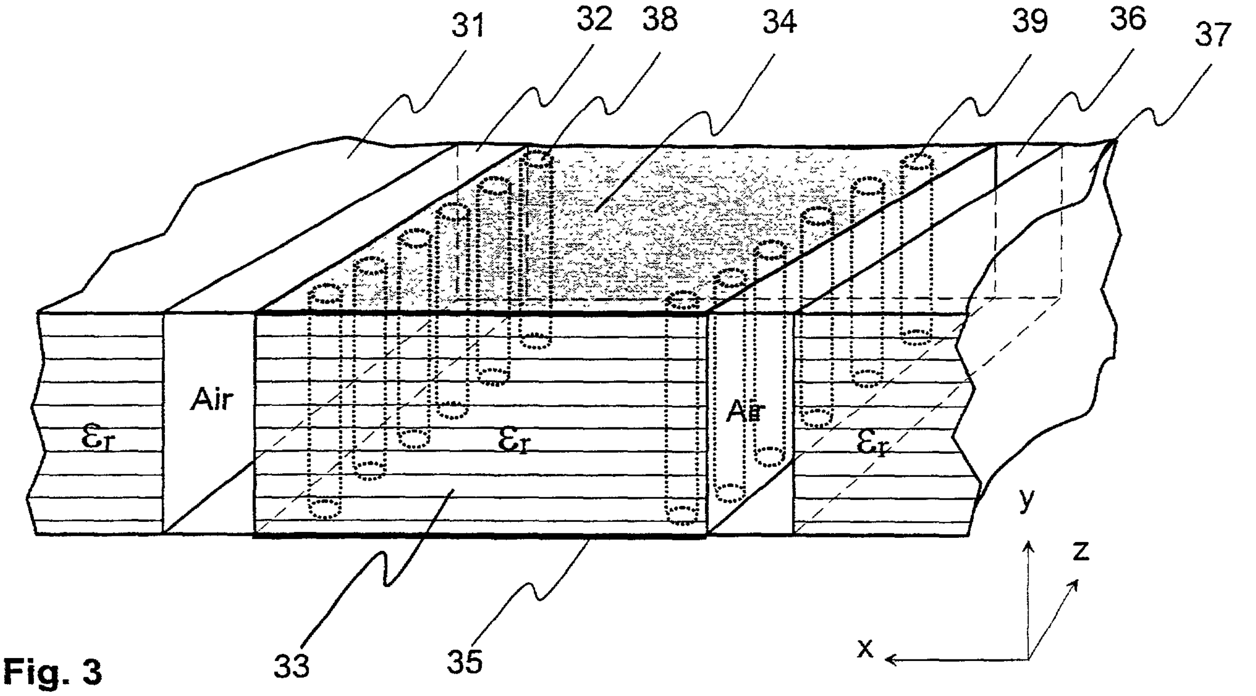
31
32
38
34
39
36
37
Air
εr
εr
Air
εr
y
z
x
33
35

Fig. 3

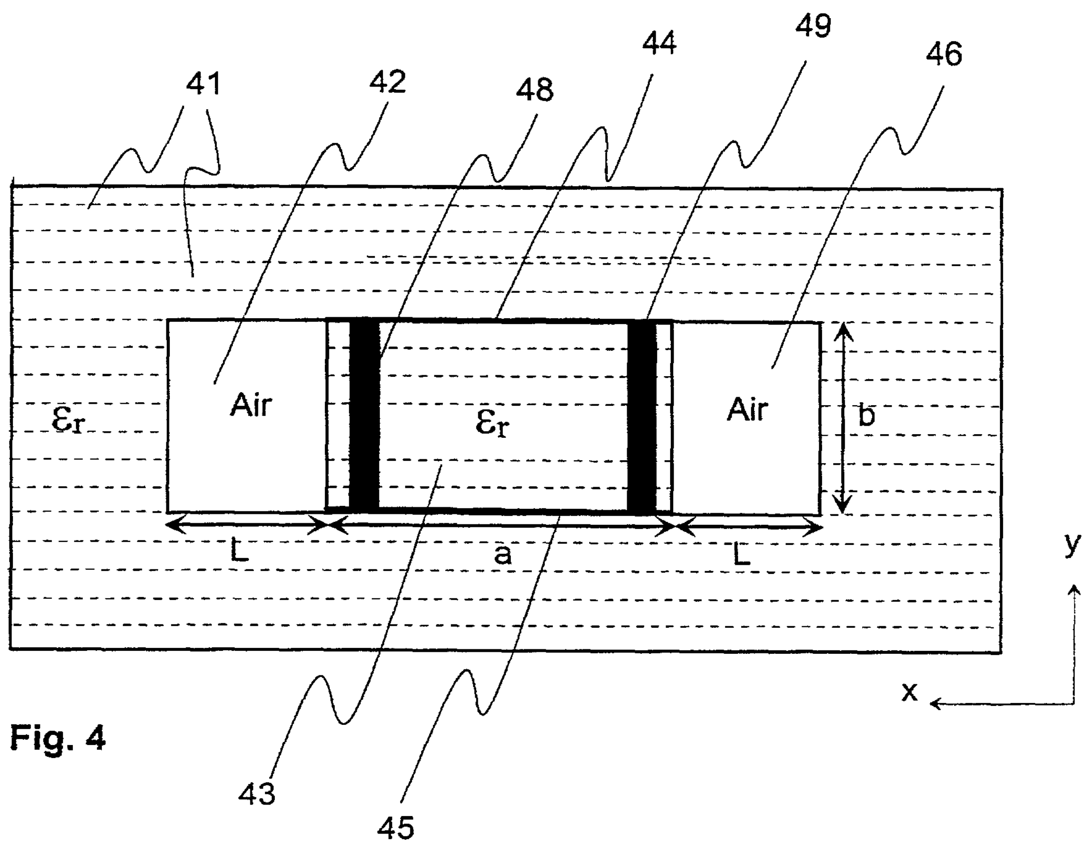
41
42
48
44
49
46
Air
εr
εr
Air
b
L
a
L
y
x
43
45

Fig. 4

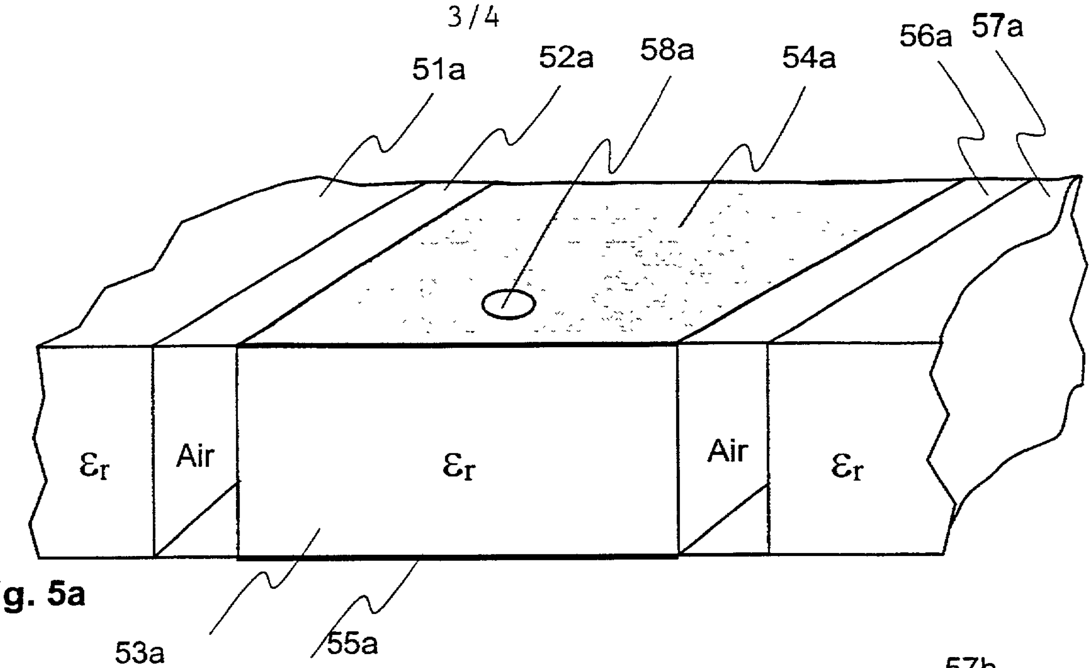

Fig. 5a

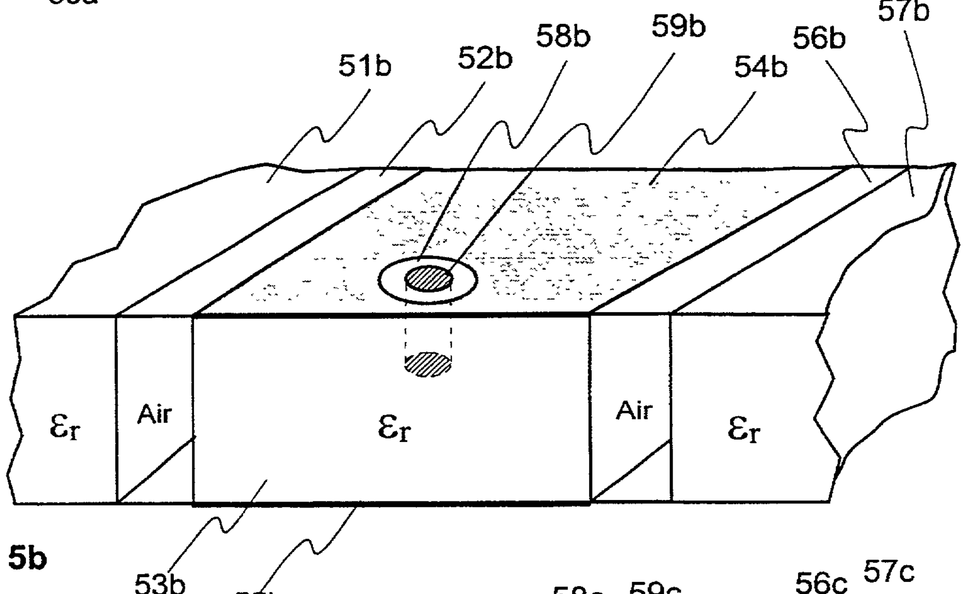

Fig. 5b

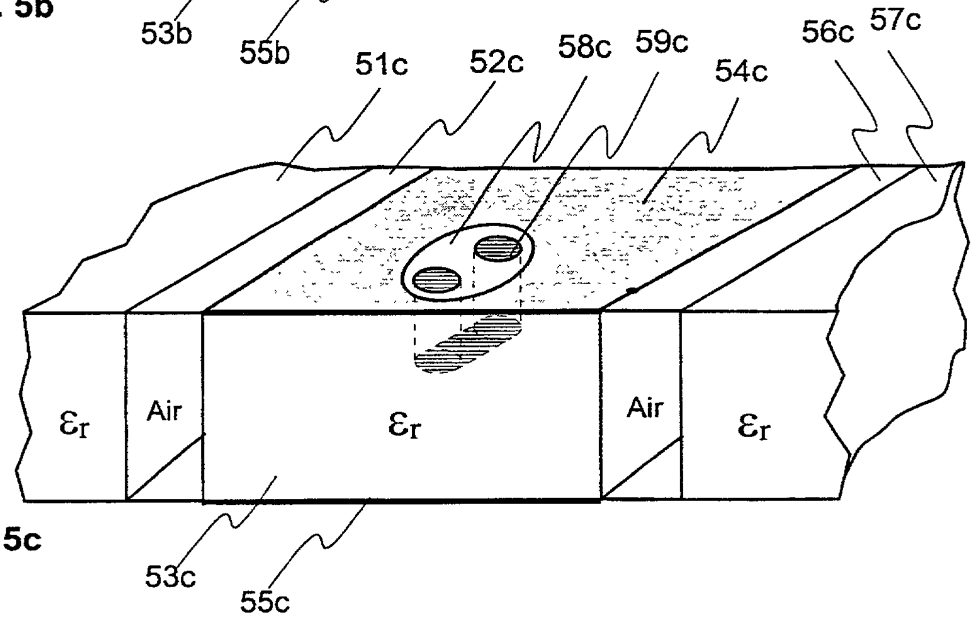

Fig. 5c

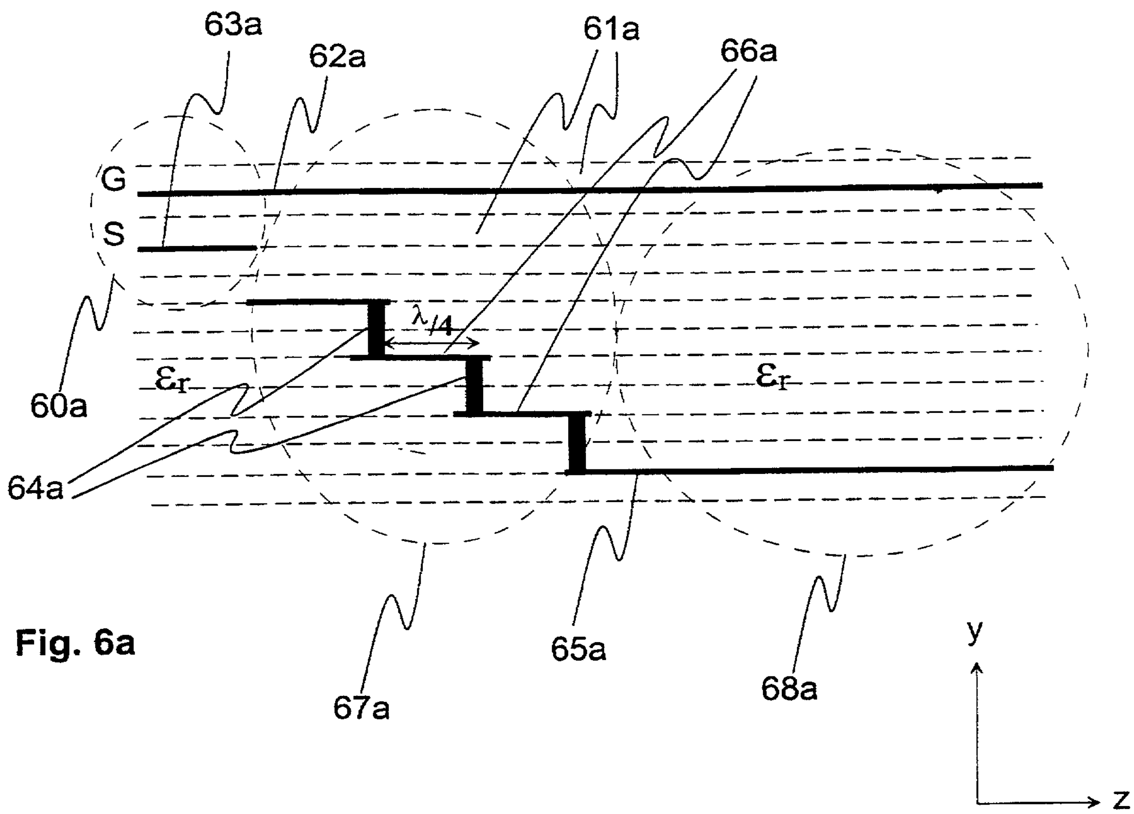
63a
62a
61a
66a
G
S
λ/4
60a
ε_r
ε_r
64a
67a
65a
68a
y
z

Fig. 6a

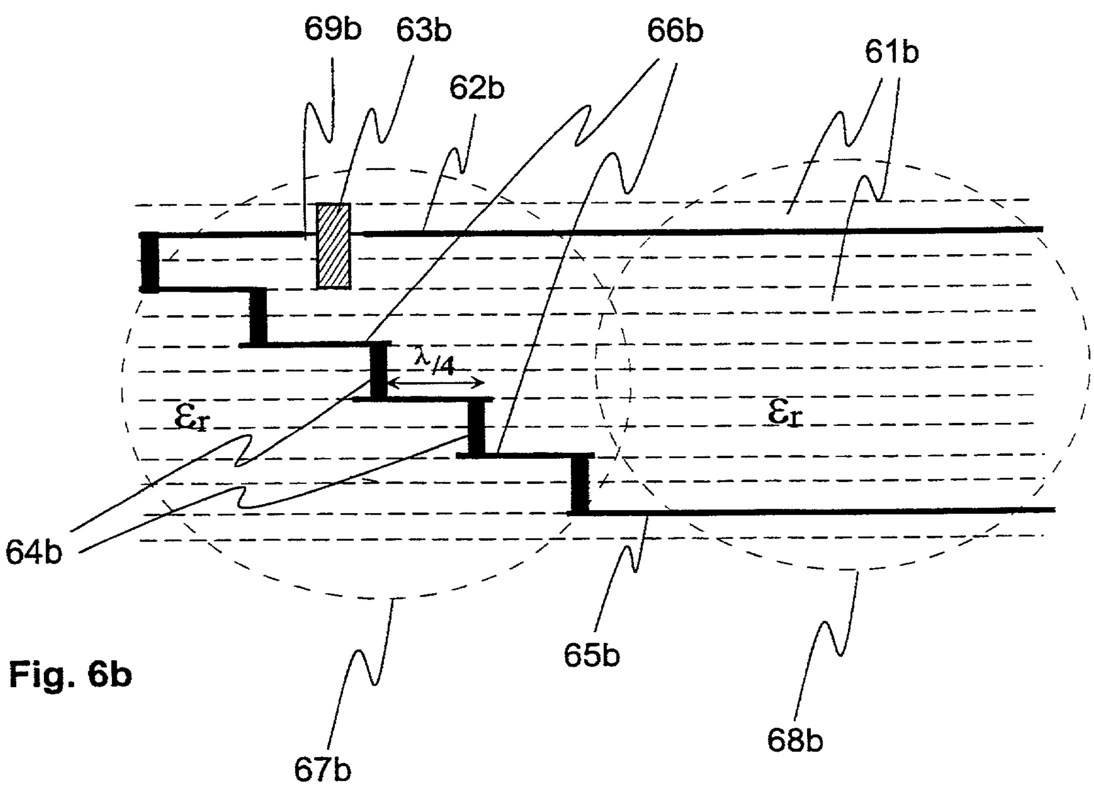
69b
63b
62b
66b
61b
λ/4
ε_r
ε_r
64b
67b
65b
68b

Fig. 6b

#4

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY Includes Reference to PCT International Applications	Attorney's Docket No. **4925-193PUS**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

the specification of which (check only one item below)

[] is attached hereto

[x] was filed as United States application

Serial No. 10/030,502

on January 8, 2002

and was amended

on _ (if applicable).

[] was filed as PCT international application

Number PCT/FI00/00635

on 10 July 2000

and was amended under PCT Article 19

on _ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of the application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

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Country (if PCT, indicate "PCT")	Application Number	Date of Filing (day, month, year)	Priority Claimed Under 35 U.S.C. 119	
Finland	991585	09 July 1999	[x] YES	[] NO
PCT	PCT/FI00/00635	10 July 2000	[x] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO

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Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	Attorney's Docket No. 4925-193PUS

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

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U.S. APPLICATIONS			STATUS *(check one)*		
U.S. APPLICATION NUMBER		U.S. FILING DATE	PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED *(if any)*			
PCT/FI00/00635	10 July 2000			x	

16

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (*List name and registration number*)

MYRON COHEN, Reg. No. 17,358; THOMAS C. PONTANI, Reg. No. 29,763; LANCE J. LIEBERMAN, Reg. No. 28,437; MARTIN B. PAVANE, Reg. No. 28,337; MICHAEL C. STUART, Reg. No. 35,698; KLAUS P. STOFFEL, Reg. No. 31,668; EDWARD M. WEISZ, Reg. No. 37,257; JULIA S. KIM, Reg. No. 36,567; VINCENT M. FAZZARI, Reg. No. 26,879; ALFRED W. FROEBRICH, Reg. No. 38,887; KENT H. CHENG, Reg. No. 33,849; ROGER S. THOMPSON, Reg. No. 29,594; GEORGE J. BRANDT, JR., Reg. No. 22,021; F. BRICE FALLER, Reg. No. 29,532 and YUNLING REN, Reg. No. 47,019.

Send correspondence to: Michael C. Stuart Reg. 35,698 Cohen, Pontani, Lieberman & Pavane 551 Fifth Avenue, Suite 1210 New York, New York 10176	Direct Telephone calls to: (name and telephone number) Michael C. Stuart (212) 687-2770

201	FULL NAME OF INVENTOR -00	FAMILY NAME SALMELA	FIRST GIVEN NAME Olli	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY Helsinki	STATE OR FOREIGN COUNTRY Finland	COUNTRY OF CITIZENSHIP Finland FIX
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Pajalahdenkatu 9 B 35	CITY Helsinki	STATE & ZIP CODE/COUNTRY FIN-00200 Finland
2-00 202	FULL NAME OF INVENTOR	FAMILY NAME KEMPPINEN	FIRST GIVEN NAME Esa	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY Helsinki	STATE OR FOREIGN COUNTRY Finland	COUNTRY OF CITIZENSHIP Finland FIX
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Vermonrinne 17 A	CITY Helsinki	STATE & ZIP CODE/COUNTRY FIN-00370 Finland

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)				Attorney's Docket No. 4925-193PUS
3-00 2 0 3	FULL NAME OF INVENTOR	FAMILY NAME SOMERMA	FIRST GIVEN NAME Hans	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY Veikkola	STATE OR FOREIGN COUNTRY Finland	COUNTRY OF CITIZENSHIP Finland FIX
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Mäkeläntie I	CITY Veikkola	STATE & ZIP CODE/COUNTRY FIN-02880 Finland
4-00 2 0 4	FULL NAME OF INVENTOR	FAMILY NAME IKÄLÄINEN	FIRST GIVEN NAME Pertti	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY Huhmari	STATE OR FOREIGN COUNTRY Finland	COUNTRY OF CITIZENSHIP Finland FIX
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Pähkinälehto 27	CITY Huhmari	STATE & ZIP CODE/COUNTRY FIN-03150 Finland
5-00 2 0 5	FULL NAME OF INVENTOR	FAMILY NAME KOIVISTO	FIRST GIVEN NAME Markku	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY Espoo	STATE OR FOREIGN COUNTRY Finland	COUNTRY OF CITIZENSHIP Finland FIX
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Taavinharju 2 E	CITY Espoo	STATE & ZIP CODE/COUNTRY FIN-02180 Finland
2 0 6	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
2 0 7	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
2 0 8	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
2 0 9	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	Attorney's Docket No. 4925-193PUS

210	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
211	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
212	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE 23.1.2002	DATE 18.1.2002	DATE 23.1.2002
SIGNATURE OF INVENTOR 204	SIGNATURE OF INVENTOR 205	SIGNATURE OF INVENTOR 206
DATE 1.2.2002	DATE 18.1.2002	DATE
SIGNATURE OF INVENTOR 207	SIGNATURE OF INVENTOR 208	SIGNATURE OF INVENTOR 209
DATE	DATE	DATE
SIGNATURE OF INVENTOR 210	SIGNATURE OF INVENTOR 211	SIGNATURE OF INVENTOR 212
DATE	DATE	DATE

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY Includes Reference to PCT International Applications	Attorney's Docket No. **4925-193PUS**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD FOR CREATING WAVEGUIDES IN MULTILAYER CERAMIC STRUCTURES AND A WAVEGUIDE

the specification of which (check only one item below)

[] is attached hereto

[] was filed as United States application

Serial No. _

on _

and was amended

on _ (if applicable).

[x] was filed as PCT international application

Number PCT/FI00/00635

on 10 July 2000

and was amended under PCT Article 19

on _ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of the application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

PRIOR FOREIGN/PCT APPLICATIONS AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

Country (if PCT, indicate "PCT")	Application Number	Date of Filing (day, month, year)	Priority Claimed Under 35 U.S.C. 119	
Finland	991585	09 July 1999	[x] YES	[] NO
PCT	PCT/FI00/00635	10 July 2000	[x] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO
			[] YES	[] NO

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	Attorney's Docket No. **4925-193PUS**

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS			STATUS (*check one*)		
U.S APPLICATION NUMBER		U.S. FILING DATE	PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S SERIAL NUMBERS ASSIGNED (*if any*)			
PCT/FI00/00635	10 July 2000			x	

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (*List name and registration number*)

MYRON COHEN, Reg. No. 17,358; THOMAS C. PONTANI, Reg. No. 29,763; LANCE J. LIEBERMAN, Reg. No. 28,437; MARTIN B. PAVANE, Reg. No. 28,337; MICHAEL C. STUART, Reg. No. 35,698; KLAUS P. STOFFEL, Reg. No. 31,668; EDWARD WEISZ, Reg. No. 37,257; VINCENT M. FAZZARI, Reg. No. 26,879; JULIA S. KIM, Reg. No. 36,567; ALFRED FROEBRICH, Reg. No. 38,887; ALFRED H. HEMINGWAY, JR , Reg. No. 26,736; KENT H. CHENG, Reg. No. 33,849; YUNLING REN, Reg. No. 47,019; ROGER S. THOMPSON, Reg. No. 29,594; BRICE FALLER, Reg. No. 29,532; DAVID J. ROSENBLUM; Reg. No. 37,709; TONY CHEN, Reg. No. 44,607; ELI WEISS, Reg. No. 17,765.

Send correspondence to:	Direct Telephone calls to: (name and telephone number)
Michael C. Stuart Reg. 35,698 Cohen, Pontani, Lieberman & Pavane 551 Fifth Avenue, Suite 1210 New York, New York 10176	Michael C. Stuart (212) 687-2770

201	FULL NAME OF INVENTOR	FAMILY NAME SALMELA	FIRST GIVEN NAME Olli	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY Helsinki	STATE OR FOREIGN COUNTRY Finland	COUNTRY OF CITIZENSHIP Finland
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Pajalahdentie 9 B 35	CITY Helsinki	STATE & ZIP CODE/COUNTRY FIN-00200 Finland
202	FULL NAME OF INVENTOR	FAMILY NAME KEMPPINEN	FIRST GIVEN NAME Esa	SECOND GIVEN NAME
	RESIDENCE. CITIZENSHIP	CITY Helsinki	STATE OR FOREIGN COUNTRY Finland	COUNTRY OF CITIZENSHIP Finland
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Vermonrinne 17 A	CITY Helsinki	STATE & ZIP CODE/COUNTRY FIN-00370 Finland

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	**Attorney's Docket No.** **4925-193PUS**

203	FULL NAME OF INVENTOR	FAMILY NAME SOMERMA	FIRST GIVEN NAME Hans	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY Veikkola	STATE OR FOREIGN COUNTRY Finland	COUNTRY OF CITIZENSHIP Finland
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Mäkeläntie 1	CITY Veikkola	STATE & ZIP CODE/COUNTRY FIN-02880 Finland
204	FULL NAME OF INVENTOR	FAMILY NAME **IKÄLÄINEN**	FIRST GIVEN NAME Pertti	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY Huhmari	STATE OR FOREIGN COUNTRY Finland	COUNTRY OF CITIZENSHIP Finland
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Pähkinälehto 27	CITY Finland	STATE & ZIP CODE/COUNTRY FIN-03150 Finland
205	FULL NAME OF INVENTOR	FAMILY NAME KOIVISTO	FIRST GIVEN NAME Markku	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY Espoo	STATE OR FOREIGN COUNTRY Finland	COUNTRY OF CITIZENSHIP Finland
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Taavinharju 2 E	CITY Espoo	STATE & ZIP CODE/COUNTRY FIN-02200 Finland
206	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE, CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
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	RESIDENCE, CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
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Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	**Attorney's Docket No. 4925-193PUS**

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	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
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	RESIDENCE, CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

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DATE	DATE	DATE
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SIGNATURE OF INVENTOR 207	SIGNATURE OF INVENTOR 208	SIGNATURE OF INVENTOR 209
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SIGNATURE OF INVENTOR 210	SIGNATURE OF INVENTOR 211	SIGNATURE OF INVENTOR 212
DATE	DATE	DATE